

IFW

PTO/SB/21 (04-04)  
Approved for use through 07/31/2006. OMB 0651-0031  
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE  
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

<b>TRANSMITTAL FORM</b>  (to be used for all correspondence after initial filing)	Application Number	10/710,254-Conf. #4253
	Filing Date	June 29, 2004
	First Named Inventor	Carlo Gemme
	Art Unit	2835
	Examiner Name	Not Yet Assigned
Total Number of Pages in This Submission	Attorney Docket Number	22106-00067-US1

ENCLOSURES (Check all that apply)				
<input type="checkbox"/> Fee Transmittal Form  <input type="checkbox"/> Fee Attached  <input type="checkbox"/> Amendment/Reply  <input type="checkbox"/> After Final  <input type="checkbox"/> Affidavits/declaration(s)  <input type="checkbox"/> Extension of Time Request  <input type="checkbox"/> Express Abandonment Request  <input type="checkbox"/> Information Disclosure Statement  <input checked="" type="checkbox"/> Certified Copy of Priority Document(s)  <input type="checkbox"/> Response to Missing Parts/Incomplete Application  <input type="checkbox"/> Response to Missing Parts under 37 CFR 1.52 or 1.53	<input type="checkbox"/> Drawing(s)  <input type="checkbox"/> Licensing-related Papers  <input type="checkbox"/> Petition  <input type="checkbox"/> Petition to Convert to a Provisional Application  <input type="checkbox"/> Power of Attorney, Revocation Change of Correspondence Address  <input type="checkbox"/> Terminal Disclaimer  <input type="checkbox"/> Request for Refund  <input type="checkbox"/> CD, Number of CD(s) _____	<input type="checkbox"/> After Allowance communication to Technology Center (TC)  <input type="checkbox"/> Appeal Communication to Board of Appeals and Interferences  <input type="checkbox"/> Appeal Communication to TC (Appeal Notice, Brief, Reply Brief)  <input type="checkbox"/> Proprietary Information  <input type="checkbox"/> Status Letter  <input checked="" type="checkbox"/> Other Enclosure(s) (please identify below):  Claim for Priority & Submission of Document (1 page); and Return Receipt Postcard		
<table border="1"><tr><td>Remarks</td><td></td></tr></table>			Remarks	
Remarks				

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT	
Firm or Individual name	CONNOLLY BOVE LODGE & HUTZ LLP Larry J. Hume - 44,163
Signature	
Date	September 29, 2004

THIS PAGE BLANK (USPTO)



Docket No.: 22106-00067-US1  
(PATENT)

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

In re Patent Application of:  
Carlo Gemme et al.

Application No.: 10/710,254

Confirmation No.: 4253

Filed: June 29, 2004

Art Unit: 2835

For: FAULT CURRENT LIMITING SYSTEM AND  
METHOD

Examiner: Not Yet Assigned

**CLAIM FOR PRIORITY AND SUBMISSION OF DOCUMENTS**

Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

Dear Sir:

Applicant hereby claims priority under 35 U.S.C. 119 based on the following prior foreign application filed in the following foreign country on the date indicated:

<u>Country</u>	<u>Application No.</u>	<u>Date</u>
European Patent Office	EP 01205190.0	December 31, 2001

In support of this claim, a certified copy of the said original foreign application is filed herewith.

Applicant believes no fee is due with this response. However, if a fee is due, please charge our Deposit Account No. 22-0185, under Order No. 22106-00067-US1 from which the undersigned is authorized to draw.

Dated: September 29, 2004  
25057\_1

Respectfully submitted,

By Larry J. Hume  
Larry J. Hume

Registration No.: 44,163  
CONNOLLY BOVE LODGE & HUTZ LLP  
1990 M Street, N.W., Suite 800  
Washington, DC 20036-3425  
(202) 331-7111  
(202) 293-6229 (Fax)  
Attorney for Applicant

**THIS PAGE BLANK (USPTO)**



**Europäisches  
Patentamt**

**European  
Patent Office**

**Office européen  
des brevets**

**Bescheinigung**

**Certificate**

**Attestation**

Die angehefteten Unterlagen stimmen mit der ursprünglich eingereichten Fassung der auf dem nächsten Blatt bezeichneten europäischen Patentanmeldung überein.

The attached documents are exact copies of the European patent application described on the following page, as originally filed.

Les documents fixés à cette attestation sont conformes à la version initialement déposée de la demande de brevet européen spécifiée à la page suivante.

**Patentanmeldung Nr.    Patent application No.    Demande de brevet n°**

01205190.0

Der Präsident des Europäischen Patentamts;  
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets  
p.o.

**R C van Dijk**

THIS PAGE BLANK (USPTO)



Anmeldung Nr:  
Application no.: 01205190.0  
Demande no:

Anmeldetag:  
Date of filing: 31.12.01  
Date de dépôt:

Anmelder/Applicant(s)/Demandeur(s):

ABB T&D Technology Ltd.  
Affolternstrasse 44  
8050 Zürich  
SUISSE

Bezeichnung der Erfindung/Title of the invention/Titre de l'invention:  
(Falls die Bezeichnung der Erfindung nicht angegeben ist, siehe Beschreibung.  
If no title is shown please refer to the description.  
Si aucun titre n'est indiqué se référer à la description.)

Fault current limiting system

In Anspruch genommene Priorität(en) / Priority(ies) claimed /Priorité(s)  
revendiquée(s)  
Staat/Tag/Aktenzeichen/State/Date/File no./Pays/Date/Numéro de dépôt:

Internationale Patentklassifikation/International Patent Classification/  
Classification internationale des brevets:

H02H9/00

Am Anmeldetag benannte Vertragstaaten/Contracting states designated at date of  
filing/Etats contractants désignées lors du dépôt:

AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE TR

THIS PAGE BLANK (USPTO)



## FAULT CURRENT LIMITING SYSTEM

### DESCRIPTION

The present invention relates to a fault current limiting device, in particular to a device for high short-circuit current interruption.

Bus-tie components able to interrupt very high short-circuit current in time period which is a fraction of current period, are known in the art.

The goal of fault current limiting components of this kind is to allow downsizing of both left and right bus-bar system, in comparison with the total short circuit current supplying a feeder as represented in figure 1.

The downsizing is reached by dimensioning each side of the switchboard for only the short circuit power of its relevant in-coming feeder. This downsizing is possible only when a very fast interrupting device is located in the bus-tie position. In case of a short circuit condition of the out-going feeder, e.g. in the right hand side of the switchboard in figure 1, the very fast interrupting device should be able to avoid any contribution to short circuit peak current coming from the other half of the switchboard not affected by fault conditions, i.e. the left hand side of the switchboard in figure 1.

This downsizing is extremely interesting in economic terms for new electrical installation, where all the new equipment can be purchased for a fraction of the total short circuit power supplying the complete

installation plant, with corresponding relevant savings. Cost savings can also be achieved in case of installation up-grade, when an existing plant has to adapted to an increase demand, thus avoiding to up-grade and change all existing apparatus.

The above-described solution can be easily implemented by simply using a fuse in the bus-tie compartment. However, the fuse technology has certain limitations and it is not always possible to have fuses with a satisfactory nominal current. Therefore, in the current practice, the use of a fuse in the bus-tie compartment is only valid for very small installations.

The solution for bigger installation foresees the use of a fuse, which is supplied only by the short circuit current, while the nominal current is normally let through a low resistance parallel element.

This parallel element is an explosive – cartridge, which is detonated at the moment the short circuit condition is detected. A control device takes care of detecting this short circuit, by both measuring the current amplitude and its rate of rise.

The present state of the art, although satisfactory for the basic needs, has some disadvantages.

At the end of the short circuit intervention, the whole system, consisting of both the explosive cartridge and the fuse, needs to be replaced before allowing the distribution system to recover the complete functionality.

This requires a maintenance operation, which takes time, and requires non-conventional spare parts, as are this explosive cartridge. During this time to maintenance, the system is operating on both side but not with the full short circuit power available, i.e. no loads are disconnected but some operating condition could not be possible due to voltage drop and startup limitations.

Also, all the working functionality is based on an explosive device, which in some countries can create difficulties in transportation and/or property permissions, or in others, simply be banned.

A further disadvantage is given by the fact that the explosive-cartridge requires an electronic control that is separated from the switchboard control system. This means in practical terms to have inside the switchboard at least two different electronic control devices with all difficulties related to this.

The goal of the present invention is to further improve the already valid present solution, by overcoming all the above-described disadvantages or limitation, keeping from the other side all of the advantages.

In particular, a further goal of the present invention is to have a system which allows automatic recovery of the complete system functionality immediately after the short circuit intervention.

Another goal of the present invention is to have a system which does not need the use of any explosive.

Still a further goal of the present invention is to have a system which integrates the specific fault current limiting control requirement inside the main switchboard control system.

These and other goals are achieved by the system according to the present invention, which relates to a novel type of fault current limiting device. The fault current limiting device of the invention is based on the use of combined fast switch and an electrical fuse in parallel; after a fault is detected the fast switch opens in a very short time and transfer the current to the fuse, which is able to blow out thereby interrupting the short-circuit current. Furthermore, an automatic system takes care of replacing the blown-out fuse set with a brand new one.

The fault current limiting system of the invention has the further following main advantages:

- It increases the perceived value of the solutions by the customer by providing full system functionality restoration in a short time.
- Increase the potential market.
- It is cheaper than the present solutions.

The invention will be now described with more details. With reference to Figure 3, the system may include of some or all, but not only, the following devices:

- Switchboard panel;
- Fast switch disconnecter;

I-0271-EP

- A number of sets of fuses;
- Fuse revolver switch;
- Circuit breaker;
- Current sensor;
- Voltage sensors;
- Voltage transformer;
- Switchboard control unit;
- Withdraw-able track.

The switchboard panel is the enclosure of the other entire components.

The fast switch device is a disconnecter having the ability to carry the nominal current for unlimited time, not having any make and break capacity.

Its major characteristics is the capacity to open in a very short time if compared with the normal electrical apparatus, let us say, in a time in the order of one millisecond.

Another important characteristic is the feature of develops a high arc voltage during the opening phase. This arc voltage is used to fast commute (in a time in the order of hundred of micro-second) the current in the parallel low resistance path where a limiting fuse is placed.

In order to be so fast during the open operation a fast and powerful drive is used. This drive can be based on Thomson coil (also called repulsion drive or electro-dynamic drive) or voice coil drive.

I-0271-EP

5

In alternative to the fast switch disconnecter an explosive based cartridge can also be used.

The system requires the use of limiting fuses. For each phase several fuses can be used in parallel.

The fuse revolver switch is a disconnecter, which function is to automatic exchange of the blown fuses at the end of the fault current limiter system opening operation on fault, avoiding in this way a long out of service of the Fault Current Limiting system in order to exchange the blown fuses with a new set.

The number of fuse sets available in the system can vary upon the expected rate of fault of the specific switchgear, or on the will to limit as much as possible the maintenance operation during time. This can vary from a minimum of 2 sets to a whatever maximum. 3 sets could be an optimum number.

The circuit breaker is used in order to;

- manage open operation made in absence of fault;
- manage open operation in case of limited fault current which does not require fault current limiter operation;
- act as final switch-off device at the end of the fault current limiter operation;
- act as a back-up in case of malfunction of the Fault Current Limiting system.

The current sensors are generic current sensor, with good response time characteristics, to make able the electronic control to detect starting fault conditions.

Voltage sensors, which can be either voltage transformers or resistive or capacitive voltage divider or any other type, in order to allow information on the voltage presence on both side of the bus-bar. These sensors are required only in case of application of the Fault Current Limiting system as bus tie current limiter and for automatic restoration of the Fault Current Limiting operation after a Fault Current Limiting system intervention.

A Voltage transformer can be used as one of the possible supply of the system. The second one can come from the substation auxiliary supply, which can have an UPS system.

The switchboard control unit is an electronic device, placed either on the switchboard panel or on the substation control room. In the first case the control is seen as distributed, in the second as centralised.

In the following all reference will describe the unit as a distributed system, but the centralised option is also possible. Task of this electronic device are various, some of them are:

- Control of all component of the system;
- Fast switch protection function;
- Classic protection function acted through circuit breaker;

I-0271-EP

7

- Measurement of electrical quantities related to the switchboard.

Some of the described components can be mounted on a track, which can be extracted from the switchboard panel when maintenance operation is required.

Advantages of this solution is:

- Easy access to all components mounted on the system;
- Fast maintenance of the panel;
- The truck itself allow to easily integrate two disconnector, which permit once the truck has been extracted, to operate on the fault current limiter system without difficulties or risk for the operator, without the need to shut down the electrical power to the complete switchboard (or one side of it ).

In alternative to the truck a standard safety disconnector can be integrated on the opposite site of the Circuit Breaker. The Circuit Breaker in this case will be himself withdraw-able, so to reach, once the safety disconnector is open and the circuit breaker withdrawn.

In normal operating conditions, the fault current limiter truck is inserted, the Circuit Breaker, the fast switch are closed, or in case of alternative solution the safety disconnector is closed, and the Circuit Breaker inserted.

In case of fault the electronic device, through the current sensor signals, analyze the estimated amplitude of the fault, by using both the amplitude



and the rate of rise of the signal. In case the foreseen fault overcome a certain threshold, than the command to open is given to the fast switch disconnector. Otherwise the signal to open is given, according to the discrimination definition, to the circuit breaker.

In case of out-going feeder protection this threshold is the max peak bearable by the switchboard, while in case of bus-tie, this is the portion of the max peak bearable by the switchboard that the opposite side of the switchboard can contribute to the fault. Furthermore, in case the switchboard is supplied by only one side because an in-coming feeder is open, then the fault current limiter can be disabled (by a blocking signal from the controller), if the remaining in-coming feeder can not supply a short circuit power which can be dangerous for the other side of the switchboard.

Once open, the Fast switch disconnector generates a relatively high arc voltage across the contact that forces the current to commute to the parallel path inside the limiting fuses and the fuse melts. After that the circuit breaker is open in its standard operating time, about 100ms., and this complete the fault current limiter open operation.

With circuit breaker open, the fuse revolver switch commutates from the present, now blown-out set of three fuses to the next one.

Now the system is ready to automatically restore the full system functionality. In case the switchboard control unit finds the system health, then the system is automatically re-close.

In case the Fault current limiter is used as a bus tie, than system health means the presence of voltage on both side of the bus bar. In case the Fault Current Limiting system is used as out-going feeder protection, than this means the impedance on the load is higher than a certain threshold.

Once the fuse revolver switch is arrived to the last position, which means no more fuse sets are available in addition to the one in service a signal is issued (either a message, for example a SMS, is sent to the control system operator or an alarm is set on) in order to call for preventive maintenance, in order to avoid not having "good" fuse to use in case of further faults.

An optional protection in case of fast switch disconnecter fault is foreseen, this protection can work on several principles, either on arc light, or on current detection or on pressure rise in the cubicle, so to inform the control system of the presence of the fault causing all of the in-coming feeder to open.

## CLAIMS

1. A fault current limiting system characterized by the fact of comprising the following components:
  - i. a fast mechanical switch or an explosive cartridge for fast operation function;
  - ii. a parallel current path comprising a limiting fuse;
  - iii. a switching system to replace the blow set of fuses with a new one after a Fault Current Limiting operation.
2. A fault current limiting system according to Claim 1, characterized by the fact of comprising several set of fuses included in the said parallel current path.
3. A fault current limiting system according to any of the previous claims, characterized by the fact that said switching system is a revolver switch.
4. A fault current limiting system according to any of the previous claims, characterized by the fact that said switching system is automatically operated by an ad hoc control system.
5. A fault current limiting system according to any of claims from 1 to 3, characterized by the fact that a dedicated control system supervises the protection logic of the Fault Current Limiting system and the control and operation of all the components.

6. A fault current limiting system according to any of the previous claims, characterized by short circuit closing capability to complete the restoration sequence of the Fault Current Limiting system after a fault.
7. A fault current limiting system according to any of the previous claims, characterized by the fact that the components of said Fault Current Limiting system are onboard a withdrawnable truck.
8. An electrical distribution switchboard comprising a fault current limiting system according to any of the previous claims.

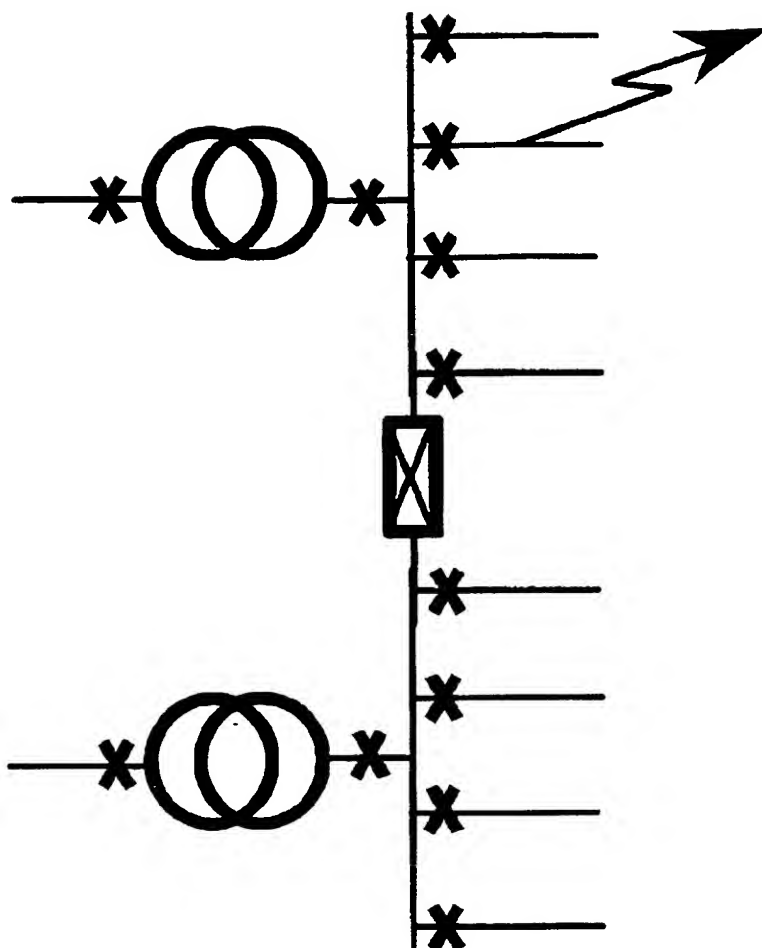


Figure 1

## FAULT CURRENT LIMITER SYSTEM

### ABSTRACT

A fault current limiting system which comprises the following components:

- i. a fast mechanical switch or an explosive cartridge for fast operation function;
- ii. a parallel current path comprising a limiting fuse;
- iii. a switching system to replace the blow set of fuses with a new one after a Fault Current Limiting operation.

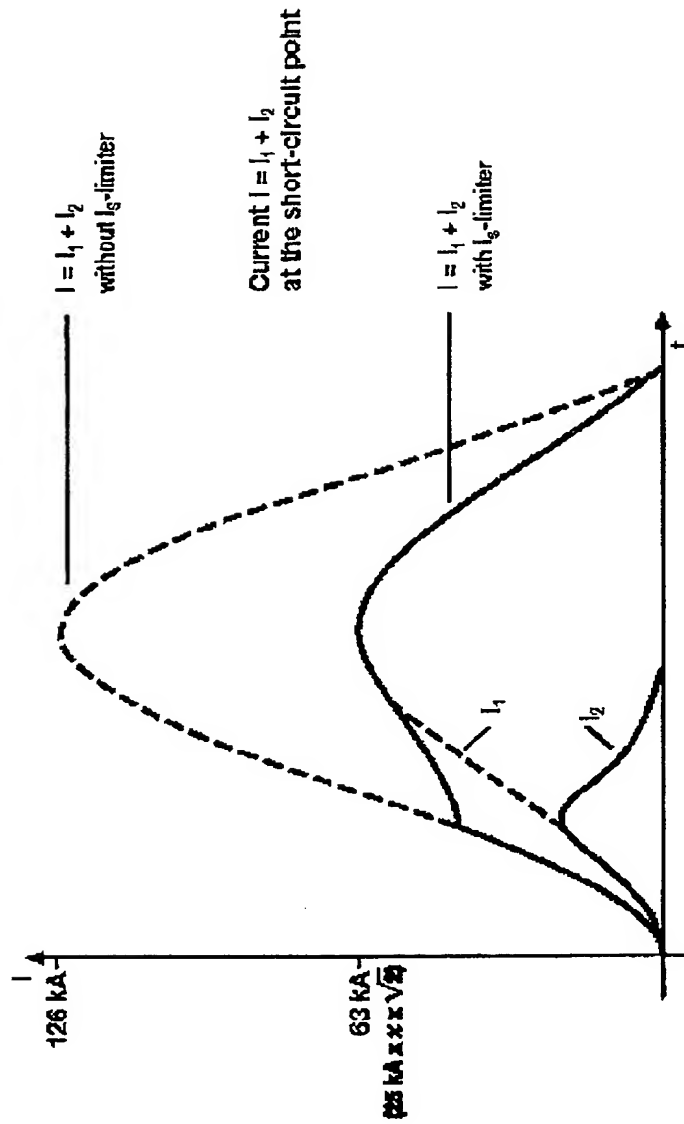


Figure 2

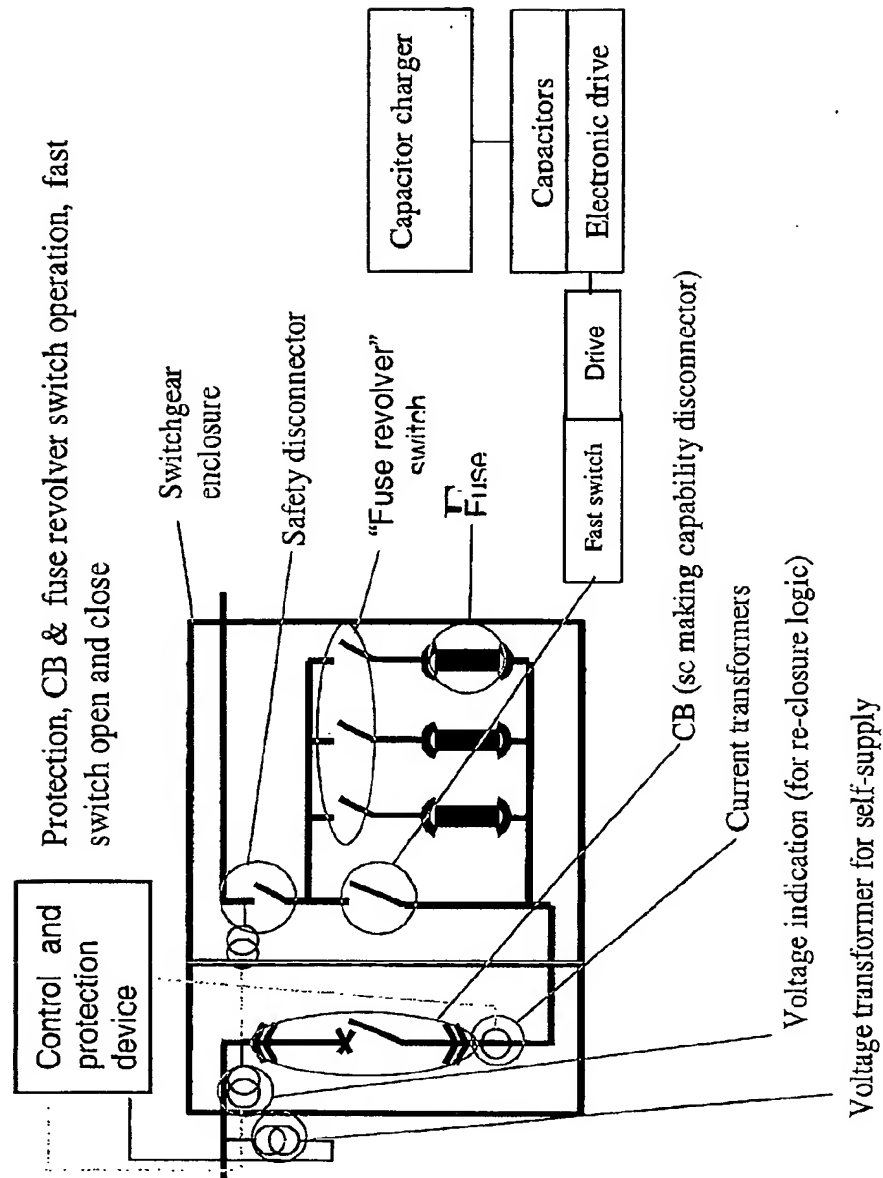


Figure 3